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**Ohkubo et al.**

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(54) **LIQUID CRYSTAL DISPLAY DEVICE**

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***G02F 1/1335*** (2006.01)
***G02F 1/1345*** (2006.01)

(52) **U.S. Cl.**
CPC ..... ***G02F 1/133615*** (2013.01); ***G02F 1/13452*** (2013.01); ***G02F 1/133308*** (2013.01); ***G02F 1/133608*** (2013.01); *G02F 2001/133612* (2013.01)

(58) **Field of Classification Search**
CPC ..... G02F 1/133308; G02F 1/133608; G02F 1/13452; G02F 2001/133334
USPC ..... 349/58, 59, 150
See application file for complete search history.

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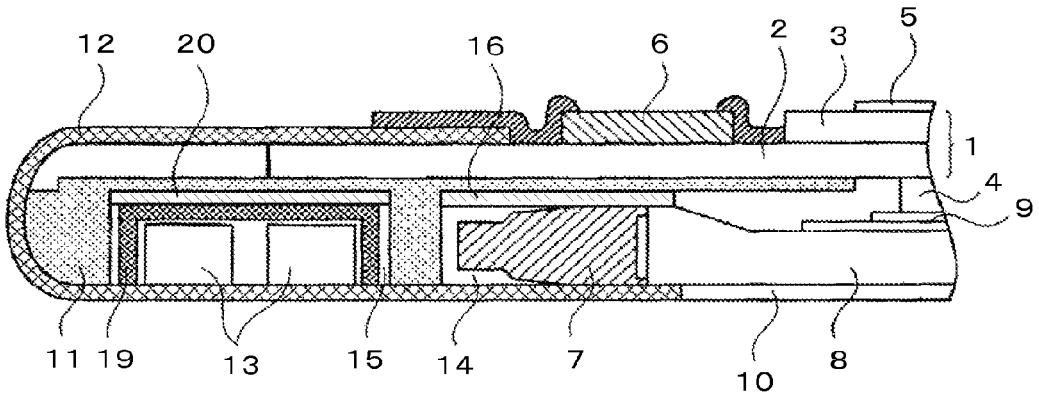
(57) **ABSTRACT**

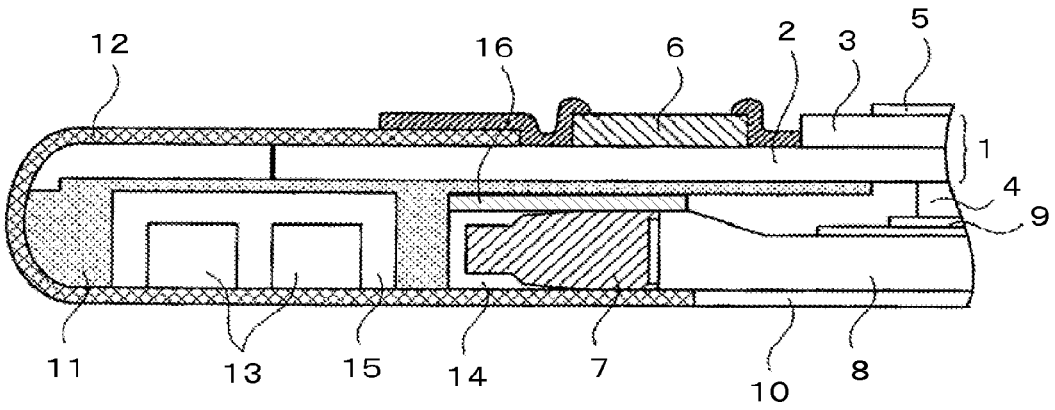
A backlight unit for a liquid crystal display device includes a light source element, a light guide plate for guiding the output light from the light source element, and a frame for housing the light guide plate. The light source element is mounted on a flexible wiring substrate fixed to the liquid crystal display panel at one end thereof, together with an electronic component. The light source element and the electronic component are attached to the frame in such a way that each of the light source element and the electronic component is placed in a housing concave portion formed on the back surface side of the frame, by bending the flexible wiring substrate. A case is fixedly attached to the flexible wiring substrate to cover the electronic component. Then, the case is fixed to the inside of the housing concave portion.

**2 Claims, 8 Drawing Sheets**



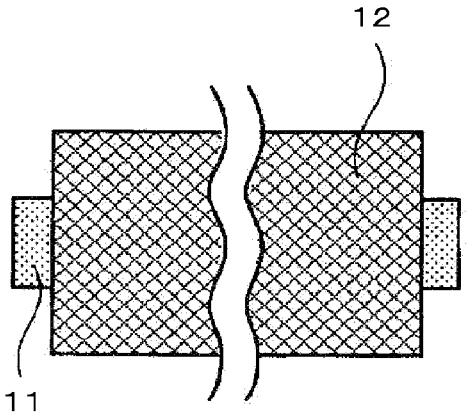
Conventional Art

FIG. 1A



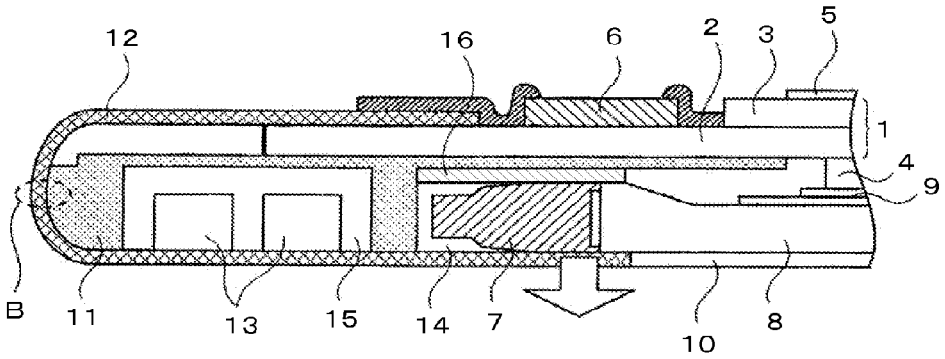

Conventional Art

FIG. 1B



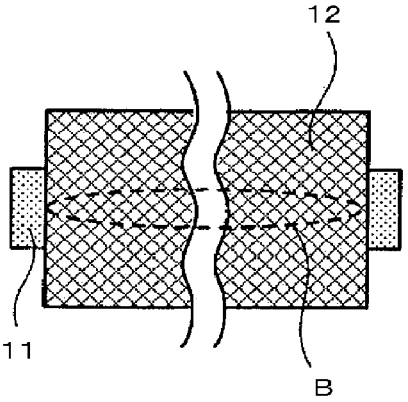
Conventional Art

FIG. 2A



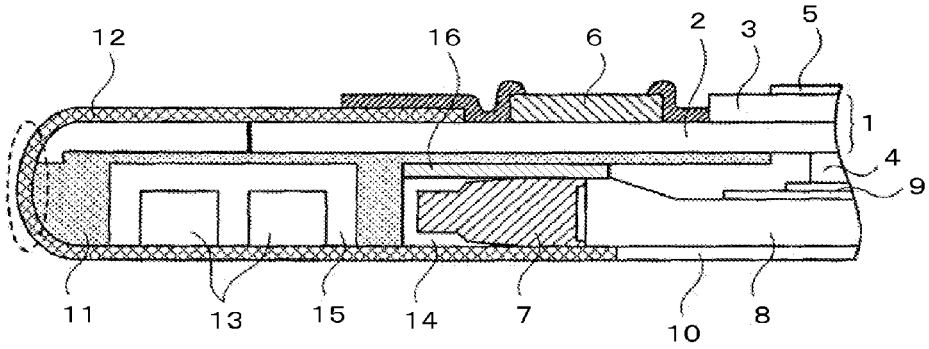

Conventional Art

FIG. 2B



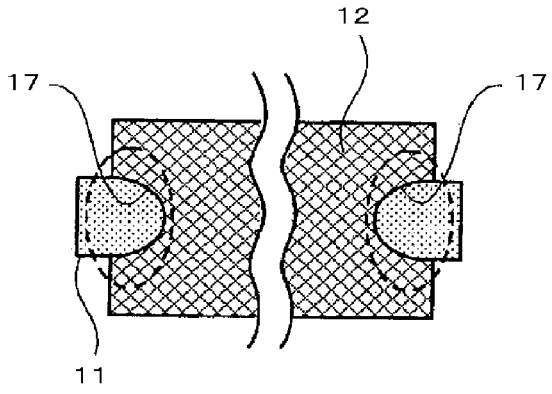
Conventional Art

FIG. 3A




Conventional Art

FIG. 3B



Conventional Art

FIG. 4

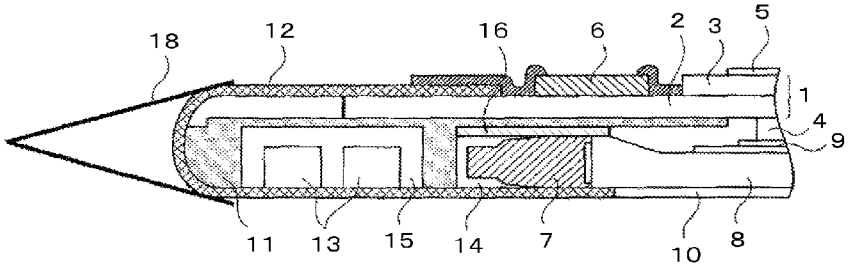



FIG. 5

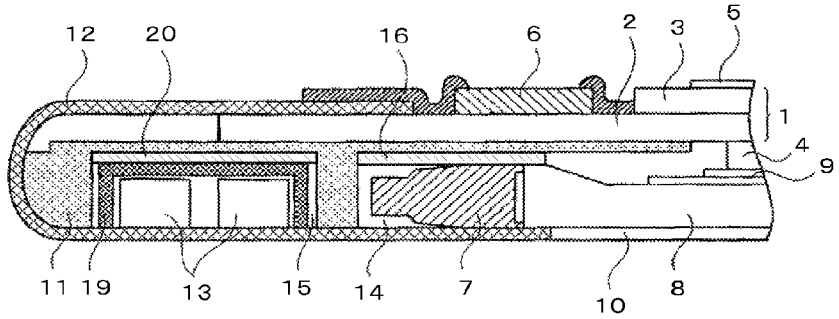


FIG. 6A

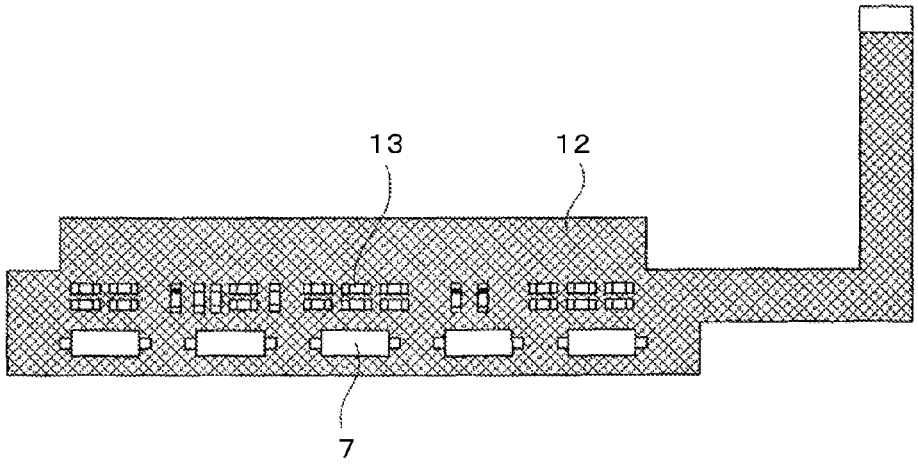



FIG. 6B

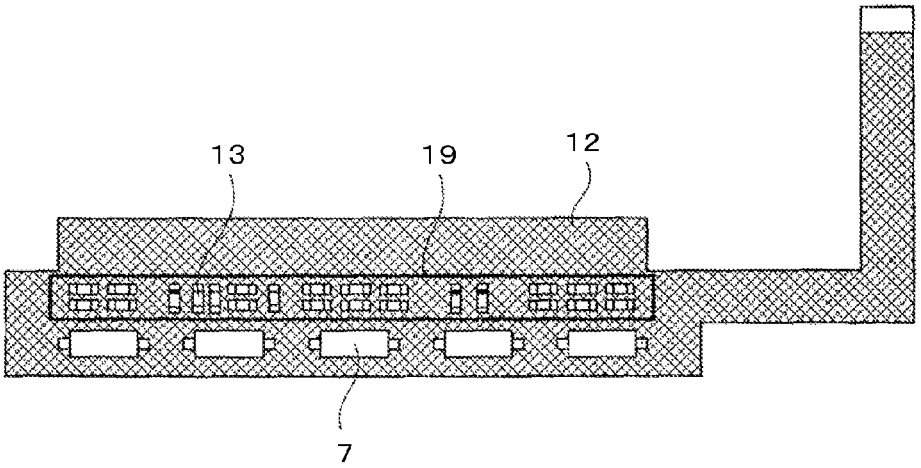


FIG. 7A

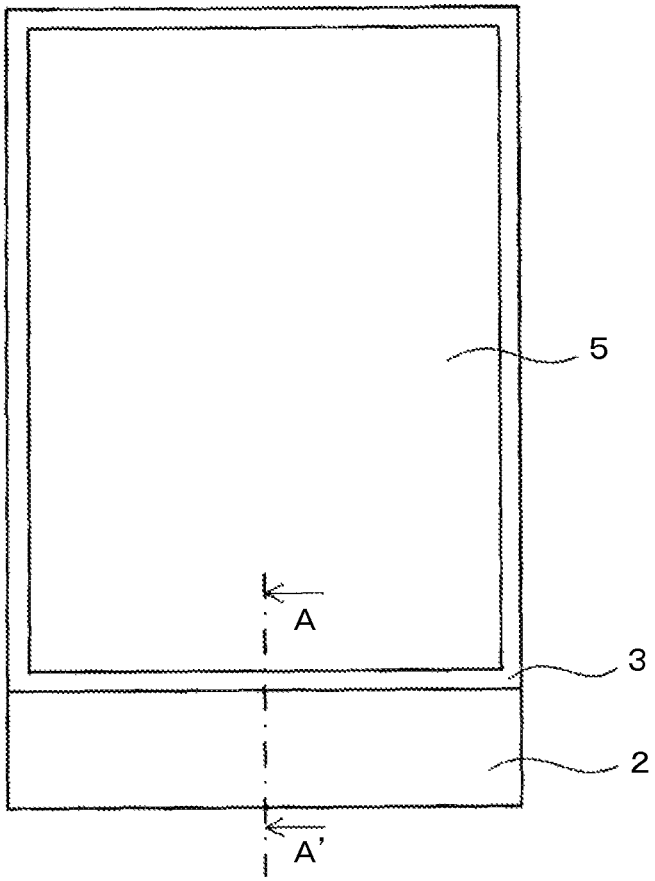



FIG. 7B

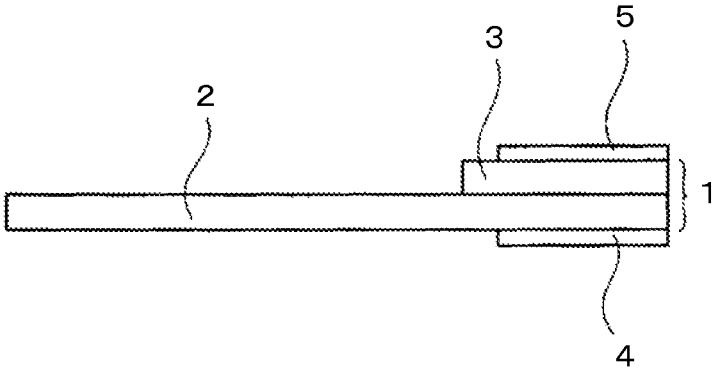


FIG. 8A

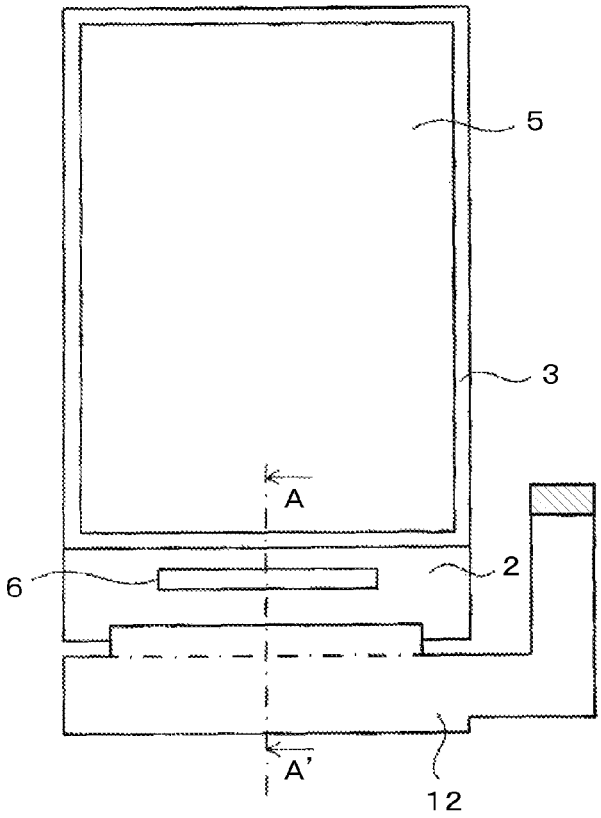



FIG. 8B

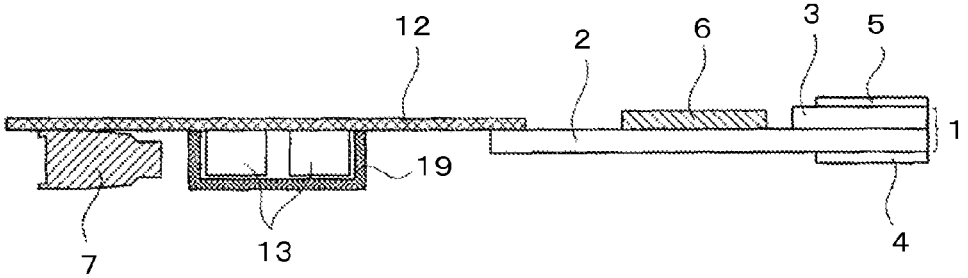


FIG. 9A

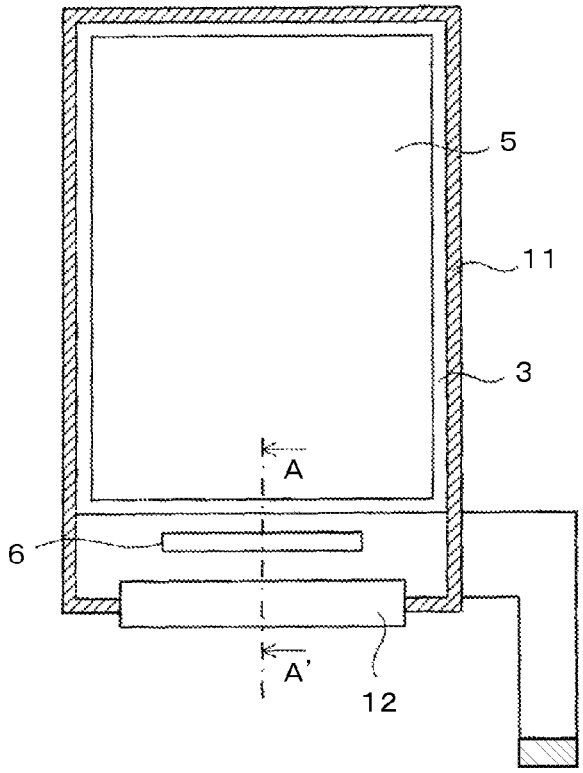
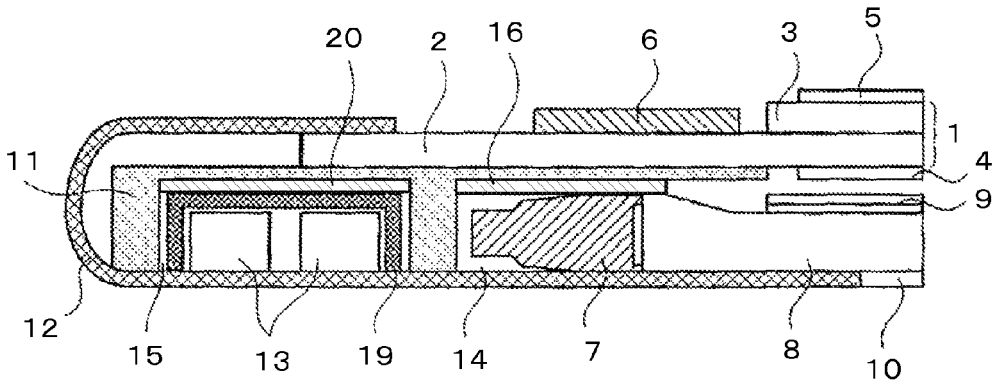



FIG. 9B



# LIQUID CRYSTAL DISPLAY DEVICE

## CLAIM OF PRIORITY

The present application claims priority from Japanese Patent Application JP 2013-120947 filed on Jun. 7, 2013, the content of which is hereby incorporated by reference into this application.

## BACKGROUND

The present invention relates to a liquid crystal display device, and more particularly, to a liquid crystal display device in which a light source element and an electronic component, which are mounted on a flexible wiring substrate, are attached to a frame in such a way that each of the light source element and the electronic component is placed in a housing concave portion provided in the frame of the backlight unit.

A thinned liquid crystal display device is used as a display device for various types of portable information devices such as mobile phones, personal digital assistants (PDA), digital cameras, and multimedia players.

A conventional liquid crystal display device will be described with reference to FIGS. **1**A to **4**.

First, an example of the conventional liquid crystal display device will be described with reference to FIGS. **1**A and **1**B.

Note that FIG. **1**A shows a cross section of the end portion in which a light source element of a liquid crystal display device is provided, and FIG. **1**B shows the liquid crystal display device seen from the left in FIG. **1**A.

The liquid crystal display device includes a liquid crystal display panel **1**, and a backlight unit provided on the back surface of the liquid crystal display panel **1**.

The liquid crystal display panel **1** is formed by a pair of transparent substrates **2** and **3**, with the space between the transparent substrates **2** and **3** filled with liquid crystal. In the transparent substrate **2**, transparent electrodes and thin film transistors are arranged to drive the liquid crystal. Then, color filters are arranged in the transparent substrate **3**. Further, a lower polarizing plate **4** is provided in the transparent substrate **2**, and an upper polarizing plate **5** is provided in the transparent substrate **3**.

Further, an edge portion of the transparent substrate **2** extends beyond the transparent substrate **3**. A driver **6** for driving the thin film transistors is mounted on the extending part.

The backlight unit includes a light emitting diode **7** as a light source element, a light guide plate **8** for guiding the light emitted from the light emitting diode **7** to the liquid crystal display panel **1** to be irradiated, an optical sheet group **9** for uniformly diffusing the light from the liquid guide plate **8** to the liquid crystal display panel **1**, a reflective sheet **10** provided on the back surface of the light guide plate **8**, and a frame-like frame **11** formed by a material having relatively high rigidity to accommodate the light source and the light guide plate.

One end portion of the flexible wiring substrate **12** is fixed to the transparent substrate **2** of the liquid crystal display panel. The flexible wiring substrate **12** is formed by a resin material and the like, and has flexibility. A circuit connected to the driver **6** is formed in the flexible wiring substrate **12**. Further, the light emitting diode **7** and an electronic component **13** such as resistance and capacitor are mounted on the flexible wiring substrate **12**.

The light emitting diode **7** and the electronic component **13** are provided on the back surface side of the flexible wiring substrate **12** in such a way that the light emitting diode **7** is located at the end portion, followed by the electronic component **13**.



A first housing concave portion **14** that is open to an end surface of the liquid guide plate **8**, as well as a second housing concave portion **15** are formed on the back side of the frame **11**. At this time, the second housing concave portion **15** is located after the first housing concave portion **14**. The light emitting diode **7** is placed in the first housing concave portion **14** so that the light emitting surface of the light emitting diode **7** faces the end surface of the light guide plate **8**. Then, the electronic component **13** is placed in the second housing concave portion **15**.

In other words, in the assembly operation of the liquid crystal display device, the flexible wiring substrate **12** is fixed to the liquid crystal display panel **1** in one end portion thereof and has a flat plate shape. The light emitting diode **7** and the electronic component **13** are mounted on this flexible wiring substrate **12**. Then, the light emitting diode **7** and the electronic component **13** are placed in the housing concave portions **14** and **15**, respectively, by bending the flexible wiring substrate **12** over one side portion of the frame **11**. Then, the light emitting diode **7** is fixed to the inner surface of the housing concave portion **14** with an adhesive layer **16** such as double-sided tape.

Thus, the liquid crystal display device is assembled with the flexible wiring substrate **12** bent as shown in FIGS. **1**A and **1**B.

The configuration in which the light emitting diode **7** and the electronic component **13** that are mounted on the flexible wiring substrate **12** are placed in the housing concave portions **14** and **15**, respectively, by bending the flexible wiring substrate **12** as described above, is a so-called full flat back in which the back surface of the liquid crystal display device is flat. Thus, there is an advantage that the configuration of the liquid crystal display device to be mounted on an actual device, such as a mobile phone, can be simplified.

However, since the flexible wiring substrate **12** is bent over the side of the frame **11**, a repulsive force acts on the flexible wiring substrate **12** by the internal stress in the direction in which the end portion thereof is removed and floated from the frame **11** as shown in FIG. **2**A by the arrow.

Thus, there is a problem that the mounting position of the flexible wiring substrate **12** is changed to displace the optical axis of the light emitting diode **7** to emit light to the light guide plate **8**, so that the brightness of the liquid crystal display device is not as good as designed.

With the reduction in size and weight of portable information devices to be implemented, the liquid crystal display device is required to be reduced in thickness and the bending diameter of the flexible wiring substrate **12** tends to be reduced. Thus, the repulsive force on the flexible wiring substrate **12** increases, so that such a failure tends to be more obvious.

As a method for preventing this failure, as shown in FIGS. **3**A and **3**B, a cutout **17** is provided around the bent portion of the flexible wiring substrate **12** in order to reduce the repulsive force generated from the bent portion of the flexible wiring substrate **12**.

However, there is a limit to the area of the cutout **17** in the flexible wiring substrate **12** due to the need to ensure the area for wiring, which has made it difficult to sufficiently reduce the repulsive force. Thus, as shown in FIG. **4**, a jig **18** is used in the assembly operation of the liquid crystal display device. In this method, the bent portion of the flexible wiring substrate **12** is held by the jig **18** to form a permanent bend in the

flexible wiring substrate **12**. However, this method may cause the line formed in the flexible wiring substrate **12** to be broken by the jig **18**.

The problem is that the thickness of the liquid crystal module increases in the configuration in which the end portion of the flexible wiring substrate with the light emitting diode overlaps the reflective sheet that is provided on the back surface of the light guide plate. In order to solve this problem, Japanese Unexamined Patent Application Publication No. 2009-216753 describes an invention to reduce the length of the end portion of the flexible wiring substrate FPC to face an end surface of the reflective sheet.

Japanese Unexamined Patent Application Publication No. 2008-203445 describes an invention to form a through-hole in the bent portion of the flexible wiring substrate to reduce the repulsive force caused by the bending of the flexible wiring substrate. However, this invention has the same problem as that in the method for forming the cutout **17** as shown in FIGS. **3**A and **3**B.

## SUMMARY

The present invention aims to rationally solve the problem and to provide a liquid crystal display device capable of stably holding a light source element placed in a housing concave portion in such a way that the light source element faces an end portion of a light guide plate.

A liquid crystal display device according to the present invention has the following technical features.

(1) A liquid crystal display device includes a liquid crystal display panel, and a backlight unit provided on a back surface of the liquid crystal display panel. The backlight unit has a light source element, a light guide plate for guiding output light from the light source element, and a frame for housing the light guide plate. The light source element is mounted on a flexible wiring substrate, together with an electronic component. One end of the flexible wiring substrate is fixed to the liquid crystal display panel. The light source element and the electronic component are attached to the frame in such a way that each of the light source element and the electronic component is placed in a housing concave portion formed on the back surface side of the frame, by bending the flexible wiring substrate. A case is fixedly attached to the flexible wiring substrate to cover the electronic component. Then, the case is fixed to the inside of the housing concave portion.

(2) In the liquid crystal display device described in (1), the case is an electromagnetic shielding case.

According to the present invention, in the liquid crystal display device in which the light source element mounted on the flexible wiring substrate is placed in the housing concave portion, it is possible to stably hold the light source element facing an end portion of the light guide plate.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B show a conventional liquid crystal display device, in which FIG. **1**A is a cross-sectional side view of the liquid crystal display device and FIG. **1**B is a front view seen from the left in FIG. **1**A;

FIGS. **2**A and **2**B are views showing a failure of the conventional liquid crystal display device, in which FIG. **2**A is a cross-sectional side view of the liquid crystal display device and FIG. **2**B is a front view seen from the left in FIG. **2**A;

FIGS. **3**A and **3**B are views showing a countermeasure method for the failure of the conventional liquid crystal display device, in which FIG. **3**A is a cross-sectional side view of the liquid crystal display device and FIG. **3**B is a front view seen from the left in FIG. **3**A;

FIG. **4** is a view of a countermeasure method for the failure of the conventional liquid crystal display device, showing a cross-sectional view of the liquid crystal display device;

FIG. **5** is a view of a liquid crystal display device according to an embodiment of the present invention, showing a cross-sectional view of the liquid crystal display device;

FIGS. **6**A and **6**B are views of a flexible wiring substrate, in which FIG. **6**A is a plan view of a conventional example and FIG. **6**B is a plan view of an embodiment of the present invention;

FIGS. **7**A and **7**B are views of the initial stage of the assembly of the liquid crystal display device according to an embodiment of the present invention, in which FIG. **7**A is a plan view and FIG. **7**B is a cross-sectional view taken along line A-A' of FIG. **7**A;

FIGS. **8**A and **8**B are views of the middle stage of the assembly of the liquid crystal display device according to an embodiment of the present invention, in which FIG. **8**A is a plan view and FIG. **8**B is a cross-sectional view taken along line A-A' of FIG. **8**A; and

FIGS. **9**A and **9**B are the final stage of the assembly of the liquid crystal display device according to an embodiment of the present invention, in which FIG. **9**A is a plan view and FIG. **9**B is a cross-sectional view taken along line A-A' of FIG. **9**A.

## DETAILED DESCRIPTION

A liquid crystal display device according to the present invention will be described in detail with reference to a preferred embodiment.

A liquid crystal display device according to an embodiment of the present invention, shown in FIG. **5**, includes a liquid crystal display panel **1** and a backlight unit provided on the back surface of the liquid crystal display panel **1**. The backlight unit includes a light source element **7**, a light guide plate **8** for guiding the output light from the light source element **7**, and a frame **11** for housing the light guide plate **8**. The light source element **7** is mounted on a flexible wiring substrate **12**, together with an electronic component **13**. One end of the flexible wiring substrate **12** is fixed to the liquid crystal display panel **1**. The light source element **7** and the electronic component **13** are attached to the frame **11** in such a way that the light source element **7** and the electronic component **13** are placed in housing concave portions **14** and **15** formed on the back surface side of the frame **11**, respectively, by bending the flexible wiring substrate **12**. A case **19** is attached to the flexible wiring substrate **12** to cover the electronic component **13**. Then, the case **19** is fixed to the inside of the housing concave portion **15**.

The basic configuration of the liquid crystal display devices according to the present embodiment shown in FIGS. **5** to **9**B is the same as the conventional liquid crystal display device shown in FIGS. **1**A to **2**B. Thus, the same components are designated by the same reference numerals, and the redundant description of the parts and functions that have been described will be omitted.

The liquid crystal display device according to the present embodiment, as will be described in detail below, has a major feature in the attachment configuration of the electronic component **13** mounted on the flexible wiring substrate **12**.

Note that in the present embodiment, similar to the conventional example, the light emitting diode **7** is used as the

light source element. However, the present invention is not limited to this example and can use various light source elements for the light source.

In the convention liquid crystal display device, the light emitting diode **7** and the electronic component **13** are exposed on the flexible wiring substrate **12** as shown in FIG. **6**A. However, the liquid crystal display device according to the present invention is designed to cover the electronic component **13** mounted on the flexible wiring substrate **12** by the case **19** as shown in FIG. **6**B.

Note that in FIG. **6**B, the case **19** is shown in a transparent manner to show the positional relationship with the electronic component **13**.

As shown in FIG. **5**, the case **19** has a box shape with one side open, covering the electronic component **13** on the flexible wiring substrate **12**. The case **19** is fixed to the flexible wiring substrate **12** by an adhesive or soldering method.

The case **19** is formed, for example, by a metal or resin and has relatively high rigidity. In particular, the case **19** is preferably an electromagnetic shielding case formed by a material having an electromagnetic shielding property.

The second housing concave portion **15** of the frame **11** has approximately the same size as the case **19**. As shown in FIG. **5**, in the liquid crystal display device that is assembled by bending the flexible wiring substrate **12**, the case **19** is placed in the second housing concave portion **15**, and the top surface of the case **19** and the bottom surface of the second housing concave portion **15** are fixed by an adhesive layer **20** such as double-sided tape.

Note that the frame **11** can be formed by molding a material such as metal and resin. The first and second housing concave portions **14** and **15** can also be formed at the time of the molding.

The liquid crystal display device according to the present embodiment is assembled by bending the flexible wiring substrate **12**, in which the light emitting diode **7** is placed in the first housing concave portion **14** and the electronic component **13**, which is housed in the case **19**, is placed in the second housing concave portion **15**. Then, in the assembling state, the light emitting diode **7** is fixed to the inner surface of the first housing concave portion **14** by the adhesive layer **16**, and the case **19** attached to the flexible wiring substrate **12** is fixed to the inner surface of the second housing concave portion **15** by the adhesive layer **20**. With this configuration, the flexible wiring substrate **12** is tightly fixed to the frame **11**.

Thus, it is possible to prevent the flexible wiring substrate **12** from being floated by the repulsive force due to the bending of the flexible wiring substrate **12**. As a result, it is possible to stably hold the light emitting diode **7** facing the end portion of the light guide panel **8**. In other words, the optical axis of the light emitting diode **7** that emits light to the light guide plate **8** prevents displacement to achieve a liquid crystal display device with the full flat back configuration in order to obtain brightness as designed.

Note that even in an aspect of not providing the adhesive layer **16** for fixing the light emitting diode **7** due to the design requirements or other reasons, the same operation effect as described above can be obtained by the adhesive layer **20** for fixing the case **19**.

Further, Electro Magnetic Interference (EMI) can cause malfunction of the liquid crystal display device and the actual device on which the liquid crystal display device is mounted. However, when an electronic shielding case is used for the case **19**, it is possible to block EMI generated by the electronic component **13**, and to prevent such a malfunction.

FIGS. **7**A to **9**B show the assembly process of the liquid crystal display device according to the present embodiment.

First, as shown in FIGS. **7**A and **7**B, a liquid crystal display panel **1** is formed by bonding a transparent substrate **2** in which thin film transistors and the like are arranged, and a transparent substrate **3** in which color filters are arranged. The space between the transparent substrates **2** and **3** is filled with liquid crystal. Then, a lower polarizing plate **4** and an upper polarizing plate **5** are attached to the back and top surfaces of the liquid crystal display panel **1**, respectively.

Next, as shown in FIGS. **8**A and **8**B, a driver **6** is provided in the transparent substrate **2**. Further, the flexible wiring substrate **12** on which the light emitting diode **7** and the electronic component **13** covered by the case **19** are mounted is fixedly attached to the transparent substrate **2** in one end portion thereof.

Next, as shown in FIGS. **9**A and **9**B, the liquid crystal display panel **1** is placed on the frame **11**, and the flexible wiring substrate **12** is bent over one side portion of the frame **11**, in which the light emitting diode **7** is placed in the first housing concave portion **14** and the electronic component **13**, which is covered by the case **19**, is placed in the second housing concave portion **15**.

The adhesive layers **16** and **20** are provided in the first and second housing concave portions **14** and **15** that are formed in the frame **11**. The liquid crystal display device is assembled in such a way that the light emitting diode **7** and the case **19**, which are placed in the first and second housing concave portions **14** and **15**, are fixedly attached to the inside of the first and second housing concave portions **14** and **15** by the adhesive layers **16** and **20**, respectively.

Note that the adhesive layers **16** and **20** can also be provided in the light emitting diode **7** and the case **19**, respectively. In this case, the light emitting diode **7** and the case **19** are placed in the first and second housing concave portions **14** and **15**, respectively, and fixedly attached to the inside of the first and second housing concave portions **14** and **15** by the adhesive layers **16** and **20**, respectively.

Further, the case **19** can be fixed to the second housing concave portion **15** in any part thereof. In particular, when the top surface of the case **19** is bonded to the bottom surface of the second housing concave portion **15** as shown in the present embodiment, the case **19** can be smoothly inserted into the housing concave portion **15** without touching the adhesive layer.

Here, in the assembly operation, when the case **19** is placed in the second housing concave portion **15**, the case **19** is guided with the outer surface of the case **19** coming into contact with the inner surface of the second housing concave portion **15**. Thus, it is possible to attach the light emitting diode **7** to the light guide plate **8** by accurately determining the position of the light emitting diode **7** with respect to the light guide plate **8** based on the case **19**.

In the present embodiment, the size of the case **19** is approximately the same as the second housing concave portion **15**, so that the case **19** is guided back and forth and left and right. In this way, the positioning action can be sufficiently achieved. Note that the positioning action can be achieved as long as any portion of the case **19** comes into contact with the inner surface of the housing concave portion **15**. Thus, in the present invention, the shape and size of the case **19** is not limited to the exemplary embodiment.

It should be understood that the present invention is not limited to the above exemplary embodiment and various changes and modifications can be made therein without departing from the scope of the present invention.

For example, in the above embodiment, the housing concave portions **14** and **15** for housing the light emitting diodes **7** and the case **19** are separated by a partition. However, in the

present invention, it is possible to eliminate the partition to integrate the housing concave portions **14** and **15** into one housing concave portion.

The present invention can be widely applied to a liquid crystal display device in which a light source element and an electronic component are mounted on a flexible wiring substrate fixed to a liquid crystal panel in one end portion thereof. The light source element and the electronic component are attached to a frame in such a way that each of the light source element and the electronic component is placed in a housing concave portion formed on the back surface side of the frame, by bending the flexible wiring substrate. For example, the present invention can be used as a display device for portable information devices such as mobile phones, personal digital assistants (PDA), digital cameras, and multimedia players.

What is claimed is:

**1**. A liquid crystal display device comprising:

a liquid crystal display panel; and

a backlight unit provided on a back surface of the liquid crystal display panel,

wherein the backlight unit includes:

a light source element;

a light guide plate for guiding output light from the light source element; and

a frame for housing the light guide plate,

wherein the light source element is mounted on a flexible wiring substrate fixed to the liquid crystal panel at an end thereof, together with an electronic component,

wherein the light source element and the electronic component are attached to the frame in such a way that each of the light source element and the electronic component is placed in a housing concave portion formed on the back surface side of the frame, by bending the flexible wiring substrate,

wherein a case is fixedly attached to the flexible wiring substrate to cover the electronic component, and

wherein the case is fixed to the inside of the housing concave portion.

**2**. The liquid crystal display device according to claim **1**, wherein the case is an electromagnetic shielding case.

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